nomena. At 18*h*. 49*m*. there was a brilliant flash nearly overhead, and after an interval of seven or eight seconds there came a dash of rain which lasted about a minute. The rain had almost ceased before the next flash. Again, at 18*h*. 51*m*., there was another strong flash, and rain occurred after three or four seconds. The general rain was quite intermittent, and I noted a similar sequence twice more, but without noting the time. The impression was strong at the time that this was clearly a phenomenon of cause and effect. I have noted the same phenomenon several times before but never so markedly as on Saturday.

On comparing this record with that of Mr. Masterman on page 304, Vol. XXV, we must conclude that lightning precedes rain and follows rain with about equal frequency. Moreover, there are far more numerous cases that will have occurred to every careful observer, where severe lightning flashes have not been closely attended by a rain gush, either before or after, so that the causal connection is not only not clearly made out but is even highly improbable.

It is still too soon to announce any positive conclusion as to the connection between lightning and rainfall. Observations, suggested hypotheses, and experimental testing of the same are still in order.

THE ORIGIN OF ATMOSPHERIC ELECTRICITY.

Almost every suggestion that has ever occurred to any one as to the origin of atmospheric electricity, and the part it plays in meteorology, has been tested over and over again during the past century with only negative results. Some of these are noted in the following paragraphs:

Volta and De Saussure suggested the evaporation of the natural waters on the surface of the globe, all of which are more or less impure, but Pouillet showed that electricity could not come from the evaporation of pure water, but might come from salt water and also from the evaporating surfaces and chemical changes incident to vegetation. De la Rive showed that vegetation was entirely insufficient, and Reiss showed that evaporation of salt water does not, of itself, produce electricity; on the other hand he showed that the friction of drops of water against the sides of a platinum vessel would produce a small amount.

The hypothesis that our electricity comes from the action of the sun in heating the atmosphere as also that it is produced by the friction of warm air against cold air have both been examined, but experiment has never been able to demonstrate the slightest trace of thermo-electricity in gases and vapors.

Schoenbein considered that the oxygen of the air might act electro-chemically upon the molecules of water of which the clouds are composed, but this again has received no experimental confirmation and could hardly account for the electricity that we find in the clearest dry air. E. Becquerel suggests the decomposition of organic matters, but this, also, is not considered sufficient. It is recognized on all sides that the evaporation of terrestrial waters may carry the negative electricity at the surface of the ground upward into the atmosphere, but this does not explain the origin of that electrified state at the surface nor the fact that the atmosphere remains positive while the earth remains negative.

De la Rive considered that the continual chemical action taking place in the interior of the globe explains the origin of terrestrial electricity and that, as beneath the ocean this action is due to infiltration of sea water, therefore, the ocean is charged with positive electricity, but the solid continents with negative. Especially in the equatorial regions would the atmosphere receive from the sea those positively electrified vapors which, after overflowing into the two hemispheres, would descend in the polar regions and produce auroras, lightning, etc. But this fascinating and comprehensive theory seems to be not at all in harmony with the recent careful observations as to the nature of the electrical distribution in latitude and over oceans and continents. It is generally acknowledged that a great amount of electrified vapor and dust is carried up in every volcanic eruption, but although the quantity is enormous yet it is not sufficient to explain the condition of the whole atmosphere, although we may thereby explain some of the variations in its general electrified condition; this volcanic electricity apparently originates in a variety of ways, especially from friction.

The fact that a magnetized body when in motion gives rise by induction to an electric current flowing through a neighboring conductor has led Rowland and S. P. Thompson to calculate the electric effect of motions, such as the wind blowing over the surface of a magnetized globe, or the effect of the rotating magnetic earth upon the ether of space in its neighborhood. But here again the electric effect turns out to be too small.

The discovery by Arrhenius that sunlight, especially the ultraviolet rays, greatly diminish the insulating power of dry air and produce what is called photo-electric dissipation and the phenomena discovered by Hallwachs that a conductor carrying a negative charge gives it up to the surrounding gas when struck by a ray of ultraviolet light have given rise to the idea that in this way the sunlight acting upon one-half of the earth's atmosphere may discharge the electricity therefrom as well as from the earth and ocean beneath the air; but this, again, has not yet been demonstrated by experiment.

Faraday and Sohncke have shown that dry crystals of ice, such as may occur in the coldest dry air, may become positively electrified by friction, as for instance by descending through the air, and Sohncke has formulated a theory explanatory of the electricity of thunderstorms as dependent upon the behavior of cirrus and cumulus clouds. The electricity is generated in the region of the isothermal surface of 32° F., but this ingenious view still waits for its confirmation. Brillouin has advanced an ingenious explanation of the origin of atmospheric electricity, based upon the action of ultraviolet light upon the crystals of ice that constitute cirrus clouds (see MONTHLY WEATHER REVIEW for 1897, p. 440), but some points in his theory remain to be established by further experimentation. P. de Heen suggests that as solar radiation illuminates and heats the earth, so it also has the power to electrify the upper strata of air; that these in fact, as it were, absorb the electric influence and then being electrified act indirectly on the ground below. Maclean and Lenard have studied the electrification of the air by drops of water falling through it. It is found that falling water drops give the air a negative charge, but so also do snow crystals; therefore, the higher strata of air should be negative instead of positive, as actually observed. Marvin observes that a rain of fine drops of mercury in dry air electrifies the drops and presumably the air. Palmieri has shown that the condensation of aqueous vapor in and of itself does not develop electricity. Gay Lussac and Pouillet did the same for all changes of condition from solid to fluid to vapor to gas, and the reverse; no electricity is developed except in the change from fluid to solid, when some solids, such as sulphur, show slight manifestations which are due to the action of the edge of the solidifying liquid on the glass vessel containing it.

The inductive action of the earth on its atmosphere is undoubtedly important, but the action of the sun, distant as it is, may be appreciable. Edlund and Siemens have advocated the solar origin of atmospheric electricity, but their hypotheses have not yet been generally accepted.

The spread of the electro-magnetic telegraph lines and the electric cables over the globe has shown that local electric currents generally flowing in an east-west direction exist everywhere in the earth, thus suggesting that the electrified condition of the atmosphere depends upon them. Clerk Maxwell in his treatise on electricity after recognizing that all other

sources are insufficient suggests that possibly the changing pressures to which the earth's crust is subjected by tidal strains may give rise to piezo-electricity sufficient to explain the negative charge of the earth; the Editor quite independently of Maxwell has elaborated this hypothesis in his Preliminary Studies. The laws of these tidal strains have been studied by Chree, Davison, Darwin, and others.

The thermo-electric currents of Peltier and the piezo-electricity so fully investigated by Gaugain are not sufficient to explain the amount of electricity represented by the currents flowing through the earth's surface, but the piezo-electric currents due to tidal strain may be quite sufficient. The latter represent the conversion of gravity into electricity.

Lord Kelvin, without touching the question as to the ultimate origin of the electrified state, shows that observed phenomena are sufficiently explained by simply recognizing the fact that the atmosphere can be treated as the dielectric of a condenser (like the glass between the two sheets of tin foil in a Leyden jar); the lower or earth's surface is negative and the upper layer of the atmosphere is positively electrified.

But without pursuing further the maze of hypotheses as to the ultimate origin of the electrified state of the atmosphere, we must conclude that this problem is too difficult for immediate solution; it is one of many that a following generation of physicists will undoubtedly cope with successfully.

If we turn to the simpler question of the meteorological phenomena that are evidently associated with atmospheric electricity, we shall find that the best physicists are not yet wholly clear as to the method of formation of lightning and auroral discharges, the phosphorescent glow of the clouds, ball lightning, and other every day phenomena. Is a cloud to be considered as one big conductor or does it insulate and separate the electrified masses on either side of it? Are the great displays to be seen on the summits of the Rocky Mountains due to the influence of the atmosphere or to something going on in the earth beneath? Are large drops really made up by the agglomeration of small cloud particles, or are both the drops and electricity formed simultaneously by the sudden dissipation of unstable molecular equilibrium that exists in supersaturated cloudy air (as suggested by the Editor in his article of 1891 in "Agricultural Science" on the "Artificial Production of Rain")? Do the larger drops of rain really possess a greater electrical density on their surfaces than the small drops and particles, or do they not rather lose their charges immediately either by evaporation or by gentle discharge to the neighboring drops? These and other questions crowd upon our thoughts; but satisfactory replies can only be given after physicists have invented appropriate methods of investigation. Meteorological observers may contribute to the solution of the problems by collecting both general data and special observations of exceptional phenomena, but the discussion of the data and the definitive decision by means of experimentation as to the merits of conflicting hypothetical explanations must be left to the leading physicists of the world.

ANOMALOUS AND SPORADIC AURORAS.

The Editor regrets that the publication of the following interesting communication has been delayed somewhat by the accumulation of material for the MONTHLY WEATHER REVIEW.

In a letter, dated Key West, November 10, 1897, Mr. H. B. Boyer, observer, Weather Bureau, said:

I have the honor to report that the following described phenomenon was observed on the 8th instant, and it is requested that its character be determined, if possible. The description is taken from the daily journal:

A singular phenomenon was observed between 9 and 10 p. m. This consisted of a beam of well-defined light stretching across the sky, similar to the rays projected by an electric search light. At first it was thought that such it was, as there are two men-of-war in the harbor; but the position and permanency of the beam precluded this idea, and it was afterwards found that the phenomenon had been noted on the war vessels. * * *

The luminous beam began at a point in azimuth 230° (counting from south to west) and stretched southward across the heavens to a point in azimuth 330°, with a slight upward tendency and a slight widening. At its northern extremity its width was about ½°, broadening to about 1° at its southern extremity. It remained fixed as regards its position relative to terrestrial objects, and it was noted that stars, in their upward course, were plainly visible through it. The inclination and altitude may be determined from the following: As the constellation of Orion passed the beam it was observed that at 9:50 p. m. the uppermost star in the "belt" and "Rigel" passed through simultaneously; in other words, a line drawn from "Rigel" to the uppermost star in the "belt" of Orion coincided with the axis of the luminous beam. The phenomenon began to fade about 9:45 p. m., and by 10:10 p. m. had disappeared, the fading process beginning at the northern end. By some the beam was seen to vibrate.

The above phenomenon of November 8, 1897, at Key West, occurred at a time when auroras were rarely observed (see the MONTHLY WEATHER REVIEW for November, 1897, Table IX, p. 513), but at the same time, according to that table, thunderstorms were unusually frequent, and the total number of reports for the whole United States was 64 on that day, being the largest number that occurred during the month; 38 thunderstorms were reported on the 7th and 59 on the 9th, so that these three days present us with one-third of all the storms that occurred during the month.

The general distribution of the reported thunderstorms on the 7th, 8th, and 9th was as follows: Illinois, 6, 15, 1, respectively; Indiana, 0, 9, 8; Missouri, 12, 8, 0; Ohio, 2, 13, 13; New York, 0, 2, 11; New Jersey, 0, 0, 8; Pennsylvania, 0, 3, 9; Tennessee, 0, 5, 1; Connecticut, 0, 0, 4; Massachusetts, 0, 0, 4. Other States report one or two only and Florida reported none. Even in Canada thunderstorms were reported at Grand Manan on the 6th and 9th.

General notes relative to the relation between lightning and auroras and anomalous phenomena relating to atmospheric electricity will be found in different numbers of the MONTHLY WEATHER REVIEW, the principal references to which are as follows: 1893, XXI, pp. 291, 292; 1894, XXII, pp. 78, 328, 509; 1895, XXIII, pp. 13, 297, 464; 1896, XXIV, p. 333.

The item on page 297 of the MONTHLY WEATHER REVIEW for August, 1895, is almost a parallel to the case reported by Mr. Boyer at Key West. It describes an auroral arch and streamer, as seen at Charleston, S. C., on August 26. The phenomenon was so unusual as to have given rise to many suspicions, but eventually it was seen there could be no doubt that this was a case of a very local aurora, such as the Editor calls "sporadic auroras," occurring beyond the confines of a region in which thunderstorms were prevailing at the time. These sporadic and local auroras must be considered as one of the mildest forms of electrical discharge in the atmosphere. It may be that the electricity distributed all over the surface of a globule of water in a cloudy mass or in a hazy sky is collected at the extremities of the spicule of ice when that globule is frozen. The auroral light therefore emanates from definite points and lines located near or above that layer in the atmosphere at which freezing temperature has just occurred. (Small globules may cool far below 32° F. before they freeze to ice needles.) This may be, and undoubtedly is a very irregular surface, but must have a close analogy to the shapes that we see depicted in the clouds and auroras themselves. The beautiful streamers of cirrus haze, as observed in the daytime, have often been compared with the beams, arches, and folds of auroral light, as seen at nighttime. It is quite plausible that both at Charleston, August 26, 1895, and at Key West, November 8, 1897, a discharge of electricity was taking place horizontally outward in all directions from an area of low pressure or